APPENDIX VIA:

COMPACTION TEST FOR EARTH-ROCK MIXTURES

1. INTRODUCTION. In Appendix VI, procedures are given for the standard effort compaction test using samples having particles finer than the 3/4-in. sieve sizes. The procedures outlined in this appendix are for the standard effort compaction test using material with particles larger * than 3/4-in. and finer than 2-in. sieve sizes. This method should be used for testing material containing particles larger than 3/4-in. * sieve sizes if these particles exceed 10 percent by weight of the total sample. If less than 5 percent by weight of the total sample is finer than the No. 200 sieve, maximum density should be determined by vibratory methods.

The test method outlined is comparable to the standard test in that (a) the compactive effort applied is 12,300 ft-lb/cu ft and (b) the equipment has been devised to maintain ratios between mold diameter, rammer diameter, and maximum particle size of the test specimen similar to those ratios used in the standard test in Appendix VI.

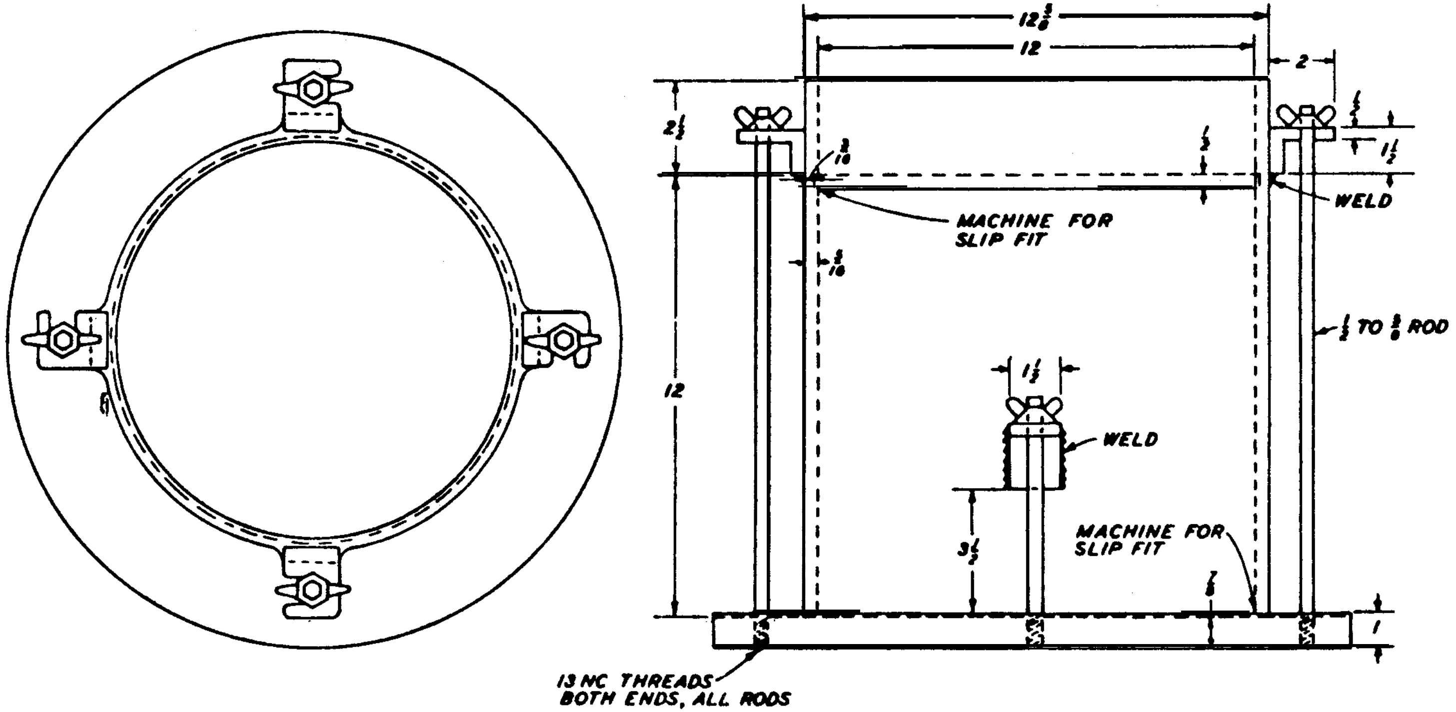
2. APPARATUS. The apparatus shall consist of the following:

a. Cylindrical mold, with an ID of 12.0 in. ± 0.1 in., a height of 12.0 in. ± 0.1 in., and a detachable collar approximately 2-1/2 in. high. The mold and collar assembly should be constructed to fasten to a detachable baseplate. Details of a typical assembly are shown in Figure 1.

b. Hand rammer, metal, of the sliding-weight, fixed-head type with a 4-in.-diameter face and a free-falling weight of ii.50 lb ± 0.05 lb. The rammer should be equipped with a guide such that the height of fall of the sliding weight is 24.00 in. ± 0.05 in. Details of a typical rammer are shown in Figure 2.

c. Balances sensitive to 0.1 lb with a capacity of 250 lb.

d. Oven, forced-draft type, 10- to 12-cu-ft capacity: automatically



PLAN

ELEVATION

NOTE: ALL DIMENSIONS ARE IN INCHES
TWO LIFTING HANDLES WELDED TO THE OUTSIDE OF THE MOLD ARE DESIRABLE.
ALL PARTS ARE HIGH-GRADE STEEL.

Figure 1. 12-in. compactior ɔld with collar and baseplate

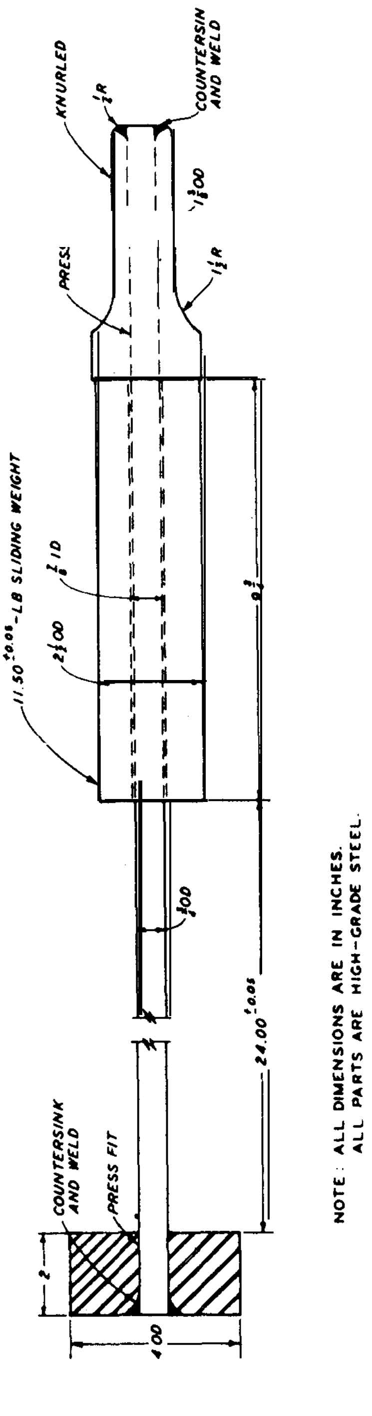


Figure 2. Compaction rammer for 12-in. mold

controlled to maintain a uniform temperature of 110 ± 5 C.

e. Pans, drying, of aluminum or other corrosion-resistant metal, with a capacity of at least 0.5 cu ft. Roasting pans 18 in. by 24 in. by 4 in. are satisfactory.

f. Sieves, U. S. Standard, large diameter type, ranging from 4-in. openings to the No. 4 size, and a mechanical sieve shaker. Sieves with 3/8-, 1/2-, 3/4-, 1-, 1-1/2-, 2-, 3-, and 4-in. openings are normally required.

g. Containers, corrosion resistant, with a capacity of at least 1 cu ft and having airtight lids.

h. Shovel, hand, square-edged, and a mortar box having a capacity of at least 4 cu ft.

i. Straightedge, steel, at least 16 in. long, 3/8 in. thick, and 1 in. wide with a beveled edge.

j. Graduates, hand scoop, trimming knife, wire brush, and rubber-head hammer.

3. QUANTITY OF SAMPLE. At least 700 lb.of sample is required having particles finer than the 2-in. sieve sizes, If the field sample contains quantities of particles larger than the 2-in. sizes, the total sample weight required must be increased to permit removal of oversize particles.

4. PROCESSING OF SAMPLE. a. Record on a work sheet (Plate VIA-l) identifying information for the sample, including visual classification.

b. Spread the material in flat pans and air-dry the entire sample. Other means, such as ovens and heat lamps, may be used to accelerate drying if the maximum drying temperature is 60 C.

c. Reduce all aggregates, or lumps formed during drying, of fine-grained material to particles finer than the No. 4 sieve. With a wire brush or other means, remove all fine-grained material that may be clinging to rock sizes, taking care not to lose the fine-grained material.

d. Separate all the material using a set of sieves ranging from the largest particle size in the sample to the No. 4 sieve. The total sample must be processed to determine the as-received gradation.

e. Place the material retained on each sieve and that passing the No. 4 sieve in separate containers, weigh the contents of each, and compute the percent of the total sample retained on each sieve as follows:

$$\%\ \text{Retained} = \frac{\text{dry weight of material retained on sieve}}{\text{dry weight of total sample}} \times 100\%$$

f. If 10 percent or less of a field sample is retained on the 2-in. sieve, the particles larger than this size should be discarded and replacement is not necessary.

g. If more than 10 percent of a field sample is retained on the 2-in. sieve, it will be necessary to remove the plus 2-in. sizes and replace them with an equal weight of material between the 2-in. and No. 4 sieve sizes. The gradation of the replacement material must be the same relative gradation as that of the total sample between the 2-in. and the No. 4 sieve sizes. The percent passing the No. 4 sieve remains constant and is equal to the percent passing the No. 4 sieve for the total as-received sample. For each sieve between the 2-in. and the No. 4 sizes, the percent required to replace the plus 2-in. sizes is computed as follows:

$$\text{Replacement } \% = \text{total } \% \text{ of } +2\text{-in. sizes} \times \frac{\%\ \text{retained on one sieve}^{\dagger}}{\text{total } \% \text{ between 2-in. and No. 4 sieve}}$$

For each sieve, add the "Replacement %" to the "% Retained" on that sieve initially. This gives the percent by weight of a test specimen required for each sieve size in order to reconstitute a specimen with the

† Any sieve between 2-in. and No. 4 sieve sizes.

+2-in. sizes replaced with sizes ranging from the 2-in. to the No. 4 sizes. Typical results are tabulated in Plate VIA-1. A typical as-received gradation and test gradation is shown in Plate VIA-2.

5. SPECIAL CONSIDERATIONS. In materials of a heterogeneous nature, such as mixtures of sandstones, siltstones, and shale, the large particles may be siltstone or sandstone, while the smaller size particles may be shale. For materials of this type, when particles larger than the 2-in. sieve sizes are removed for preparation of the test specimen, replacement must be made using the same types of materials "scalped off," or removed. For example, oversize sandstone particles must be removed and replaced, where applicable, with smaller particles of sandstone.

6. PREPARATION OF TEST SPECIMEN. a. Prepare 130 lb of processed air-dried material for the test specimen by combining the weight of material required from each sieve size (refer to typical work sheet, Plate VIA-1).

b. Thoroughly mix the material for the test specimen with a measured quantity of water sufficient to produce a water content 4 or 5 percentage points below the estimated optimum water content of the entire sample. This can be determined only by judgment and experience.

c. Store the moistened sample in an airtight container for a minimum of 16 hr.

d. Prepare material for at least four additional test specimens by repeating steps in paragraphs 6a through 6c. Increase the water content of each specimen by approximately 2 percentage points over that of the previous specimen.

7. COMPACTION PROCEDURE. a. Weigh the compaction mold to the nearest 0.1 lb, determine its inside volume to the nearest 0.001 cu ft, and record the data.

b. Attach the collar to the compactor mold, clamp the mold securely to the baseplate and place the assembly on a level, rigid foundation made of a concrete cube having a total weight of at least 200 lb. This concrete foundation should not be covered with a rnetal plate.

c. Mix the cured material thoroughly to attain a uniform water distribution.

d. Place a sufficient quantity of the test specimen in the mold to give a compacted layer between 4.0 and 4.5 in. thick. Compact each layer by applying 140 uniformly distributed blows of the rammer, with the 11.5-lb weight falling freely from a height of 24.0 in compact three equal layers in this manner, taking care to seat the rammer face flush with the soil surface before each blow and to keep the rammer assembly vertical during testing. Use just enough material to finish with less than 1 -in. of sample protruding above the top of mold.

e. Detach the extension collar, taking care not to disturb the soil mass extending above the top of the mold. Trim the surface exactly even with the top of the mold. Fill any cavities formed by removal of particles during trimming with material from the trimrnings and press this filling material firmly into place. Clean excess material from the lip of the mold.

f. Weigh the mold and compacted specimen to the nearest 0.1 lb and record the data.

g. Remove the entire test specimen from the mold, spread it in flat drying pans, and determine its water content. For most specimens, this requires at least 16 hr oven-drying time. Shorter drying times may be used if a constant weight is attained.

h. Repeat the steps in paragraphs 7c through 7g for a sufficient number of specimens over a range of water contents to establish the optimum water content and dry density. Five specimens will usually define the compaction curve accurately. Fresh material, not previously compacted, should be used for all tests.

i. For tests in which degradation of particles due to compaction is significant, determine the after-compaction gradation of at least two total specimens from each test series.

8. COMPUTATIONS. The computations shall consist of the following:

a. Compute the water content of each compacted specimen as follows :

$$\text{Water content, } w, \% = \frac{W_w}{W_s} \times 100$$

where

W_w = wet weight of total specimen minus its oven-dry weight (lb)

W_s = oven-dry weight of specimen (lb)

b. Compute the dry unit weight of each compacted specimen as follows:

$$\text{Dry unit weight, } \gamma, \text{ pcf} = \frac{W_s}{V}$$

where V = volume of the compaction mold (cu ft).

9. PRESENTATION OF RESULTS. Present the results of the test on ENG FORM 2091.

a. Compaction Curve. Plot the dry unit weight, in pounds per cubic foot, as the ordinate and the corresponding water contents, in percentages of dry weight, as the abscissa, on an arithmetic plot. Connect the plotted points with a smooth curve. The water content at the peak of the curve is the optimum water content and the corresponding dry unit weight is the maximum. Record the optimum water content to the nearest 0.1 percent and the maximum dry unit weight to the nearest 0.1 pcf.

b. Zero Air Voids and 90 Percent Saturation Curves. Using the weighted average of the specific gravity of the plus No. 4 and the minus No. 4 material, compute and plot the zero air voids curve and the curve representing the line of 90 percent saturation.

10. POSSIBLE ERRORS. The following errors can cause inaccurate results:

a. Aggregations of air-dried soil not completely reduced to finer particles during processing.

b. Water not thoroughly absorbed into dried material due to insufficient mixing and curing time.

c. Material reused after compaction.

d. Insufficient number of tests to define compaction curve accurately.

e. Improper foundation for mold during compaction.

f. Incorrect volume or weight of compaction mold.

g. Incorrect rammer weight and height of fall.

*h. Excessive material extending into the extension collar at the end of compaction.

i. Improper or insufficient distribution of blows over the soil surface.

j. Tendency to press the head of the rammer against the specimen before letting the weight fall.

k. Insufficient drying of sample for water content determination.

*To eliminate the need for trimming away the excess material extending into the collar, an alternative may be used. Determine, using the sand-cone method, the volume of the empty collar above the top of the mold and the volume of the collar partially filled with the protruding specimen. The difference is the volume of the compacted excess material. Weigh the entire specimen without trimming the excess and determine the moist unit weight.

PROJECT ____________
LAB. NO. ____________
DATE ____________
TESTED BY ____________

COMPACTION TEST
WORK SHEET

TRIAL NO.	WET WT SPECIMEN & MOLD LB	MOLD WEIGHT LB	SPECIMEN WET WT LB	MOISTURE CONTENT WT OF WATER LB	MOISTURE CONTENT PERCENT MOISTURE	SPECIMEN DRY WT LB	VOLUME OF MOLD (SPECIMEN) FT³	DRY DENSITY LB/CU FT
1	156.3	64.2	92.1	3.7	4.2	88.4	0.783	112.9
2	163.6	64.2	99.4	5.5	5.9	93.9	0.783	119.9
3	171.7	64.2	107.5	8.1	8.1	99.4	0.783	126.9
4	171.8	64.2	107.6	10.0	10.2	97.6	0.783	124.6
5	168.8	64.2	104.6	11.0	11.8	93.6	0.783	119.5

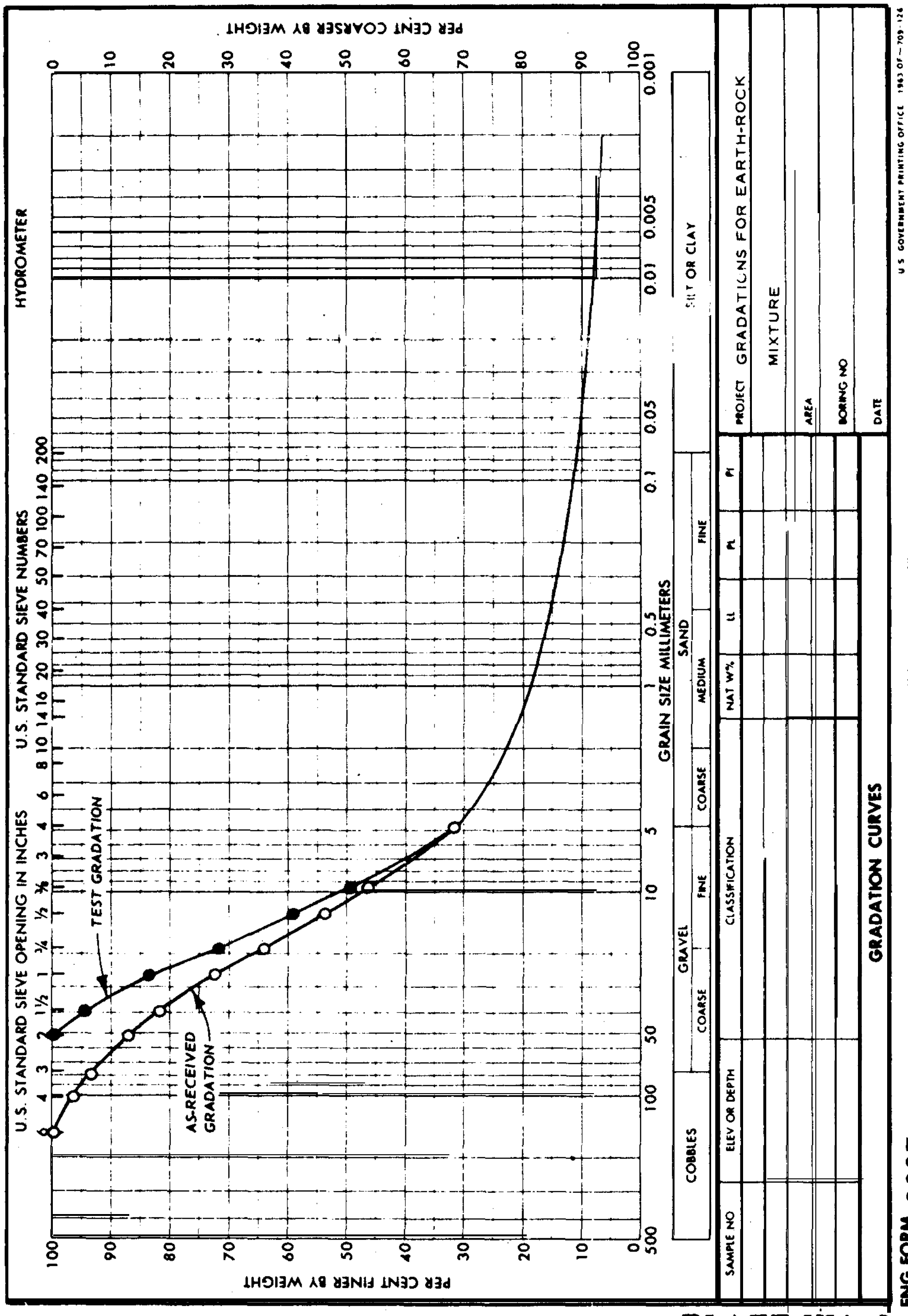
GRADATION

SIEVE SIZE	ORIGINAL SAMPLE WT RETAINED	ORIGINAL SAMPLE % RETAINED	TEST SPECIMEN % ORIGINAL	TEST SPECIMEN % REPLACEM'T	TEST SPECIMEN % TOTAL	WT FOR COMPACTION SPECIMEN
2"	104.0	13.0	0.0	0.0	0.0	0.0
1-1/2"	40.0	5.0	5.0	1.2	6.2	8.1
1"	72.0	9.0	9.0	2.1	11.1	14.4
3/4"	72.0	9.0	9.0	2.1	11.1	14.4
1/2"	80.0	10.0	10.0	2.2	12.2	15.9
3/8"	64.0	8.0	8.0	1.9	9.9	12.9
#4	120.0	15.0	15.0	3.5	18.5	24.0
PAN	248.0	31.0	31.0	0.0	31.0	40.3
TOTAL	800.0	100.0	87.0	13.0	100.0	130.0

REMARKS 140 BLOWS/EACH OF 3 LAYERS WITH 11.5-LB RAMMER AND 24-IN. DROP. DIAMETER OF MOLD = 12 IN.

STANDARD ✓
MODIFIED ____

PLATE VIA-I


U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PER CENT COARSER BY WEIGHT
PER CENT FINER BY WEIGHT
GRAIN SIZE MILLIMETERS
TEST GRADATION
AS-RECEIVED GRADATION
COBBLES
GRAVEL
COARSE
FINE
SAND
MEDIUM
SILT OR CLAY
SAMPLE NO
ELEV OR DEPTH
CLASSIFICATION
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PI
PROJECT GRADATIONS FOR EARTH-ROCK
MIXTURE
AREA
BORING NO
DATE
GRADATION CURVES
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REPLACES WES FORM NO 1241, SEP 1962, WHICH IS OBSOLETE.
(TRANSLUCENT)

PLATE VIA-2